National Engineers Week
Ventura – Santa Barbara Counties

2013 ASME Project of the Year (POY) Nomination Form
Submissions due by Friday, January 18, 2013
to asmechannelislands@gmail.com

Project Name/Title MR338 MRI Compatible Absolute Positon Sensor

Nominated by (Association/Sponsor) Dennis Horwitz, MICRONOR INC.

Project Manager(s) (name and title of person receiving project award):
Robert Rickenbach, President/Chief Engineer, Micronor Inc.

Project Team:
Robert Rickenbach, President/Chief Engineer, Micronor Inc.
Everton Freitas, Sr. Electrical Engineer, Micronor Inc.
Daniel Montes, Electrical Engineer, Micronor Inc.
Ron Boyer, Mechanical Engineer, Ron's Design Services

Brief Description of Project (please limit to one paragraph – 3-5 sentences):
The Micronor MR338 Fiber Optic Absolute Position Sensor is a non metallic and non electronic sensor which can be safely used within the strong magnetic fields of an MRI machine. This MRI-compatible absolute rotary encoder has 13-bit (8192) of resolution per 360° resulting in a resolution of 0.044° and an impressive precision of ±1bit.

The position sensing is performed entirely within the optical domain so that the sensor is entirely passive. The key to this high performance is that the position information is embedded into the optical spectrum and is thus unaffected by varying losses due to bending of the fiber optic link. The passive sensor is connected to the active MR330-1 controller via a duplex optical fiber link with a span of up to 300m.

Following the release of the original metallic MR332 sensor system, the medical community began asking for an MRI compatible version. To create an MRI compatible version of the sensor was a major engineering effort in itself – it was much more than substituting plastic for metal. The development of the MR338 sensor involved a diligent research effort for finding an appropriate materials which is non metallic and non conductive and yet can keep micrometer accuracy over a wide temperature range. Secondly, a non metallic shaft seal needed to be invented. The shaft seal is required because the encoder must be dust and water sealed to protect the optical system.

Key points of Project that merit recognition as project of the year:

1. The fundamental optical technique for the absolute encoder was 5 years in development (patent pending) with commercial release of conventional metallic version in May 2011. It then took another 1.5 years - until Dec 2012 - to find the most suitable material and

fabrication method for a non-metallic version of the high precision, complex optical assembly. The overall design is a translation of an innovative optical technique to a precision mechanical implementation.

2. A shaft seal consisting of only non metallic material was invented that operates over a wide temperature range and accommodates shaft speeds in excess of 2500 rpm. To our knowledge, this is the first commercially-available MRI compatible absolute rotary encoder.

3. The project encompassed sophisticated, multi-element optical design using Z-Max which was then was electronically imported into SolidWorks to produce the mechanical design for the sensor’s internal optical pick-up assembly.

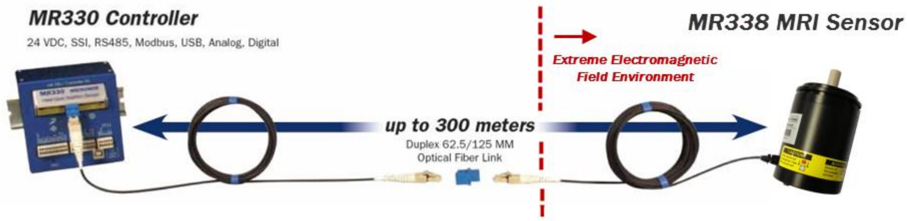
4. For MRI compatibility, the optical assembly needed to be non-metallic for which the material must be extremely stable over temperature, humidity and time. Internally the sensor accurately resolves down to 4µm thus any shift of the material introduces an error in position reading. There are plastic materials that have a suitable low temperature coefficient (Peek), however they exhibit hygroscopic property which means they change size based on moisture content. With that knowledge gained, the material of choice points toward ceramics however the complexity of the optical assembly precluded machining ceramic due to cost. It took about 18 months of research and testing to find the right material. Ultimately a suitable ceramic-like material was found which can be formed using the stereo lithographic fabrication technique and is cost effective for manufacturing. This finding and out-of- the-box thinking indicates that the future of 3D printing is more than a mere prototyping tool.

5. For the shaft seal a deliberate search for a material combination which can withstand friction and heat over the product lifetime was found. Micronor will keep this formula proprietary!

6. The product enables a wide range of internal MRI machine enhancements dependent on precision position sensing as well as functional MRI (fMRI) which can lead to improved treatment and rehabilitation techniques for impaired individuals affected by injury, strokes, heart attacks, etc. By being transparent to electromagnetic fields, the sensor can also be deployed in EMC test, radar and other challenging electromagnetic sensitive applications.

<u>Please attach a few photos or a pictorial representation of project suitable to include in brochure (*.jpg files preferred)</u>

Fiber Optic Absolute Position Sensor



- Non-Metallic for use in extreme electromagnetic environments
- Passive optical design
- Absolute angular position over 0-360° with 13-bit resolution
- 12-bit multiturn tracking
- Immune to EMI, RFI, lightning and atmospheric discharge
- Outdistances copper – links up to 300 meters
- Intrinsically Safe
- Wide Temperature Range: -40°C to +80°C

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Key Points of the Product Development

1. The overall design is a translation of an innovative optical technique to a precision mechanical implementation.

2. The fundamental optical technique for the absolute encoder was 5 years in development (patent pending) with commercial release in May 2011. It took another 1.5 years (until December 2012) to find the suitable material and fabrication method for the MRI version.

3. A sophisticated multi-element optical design using Z-Max was imported into SolidWorks to produce the mechanical design for the sensor's internal optical pick-up assembly.

4. For MRI compatibility, the optical assembly required a suitable non-metallic material which would be extremely stable over temperature, humidity and time. Plastics tended to hydroscopic. After an 18-month investigation, the ultimate solution was a ceramic-like material.

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Key Points of the Product Development

5. The material allowed the optical pick-up assembly to be formed with stereo lithographic fabrication technique and proves cost-effective for manufacturing. 3D printing has a quite a future!

6. A shaft seal consisting only of non-metallic material was invented that operates over a wide temperature range and speeds up to 2500 RPM. The shaft seal must withstand friction and heat over the product lifetime and required extensive design and testing.

7. The product enables a wide range of MRI machine enhancements dependent upon precision position sensing. By being transparent to electromagnetic fields, the sensor can also be deployed in EMC test, radar and other challenging electromagnetic sensitive applications.

8. The product also enables functional MRI (fMRI) research which can lead to improved treatment and rehabilitation techniques for impaired individuals affected by injury, strokes, heart attacks, etc.

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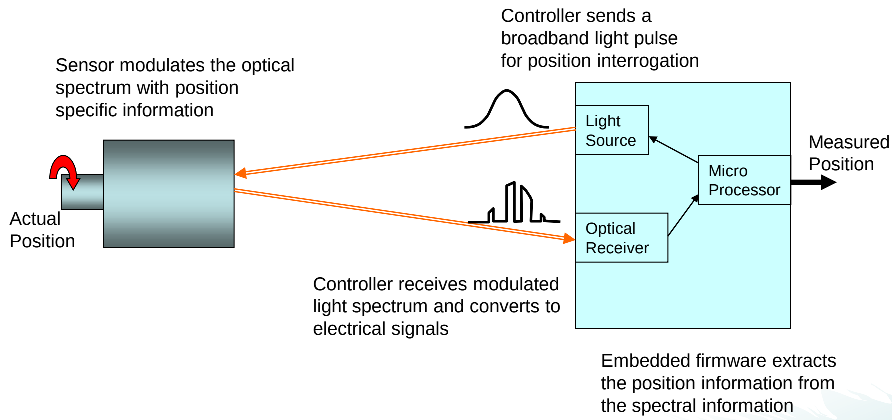
How The MR330 Works



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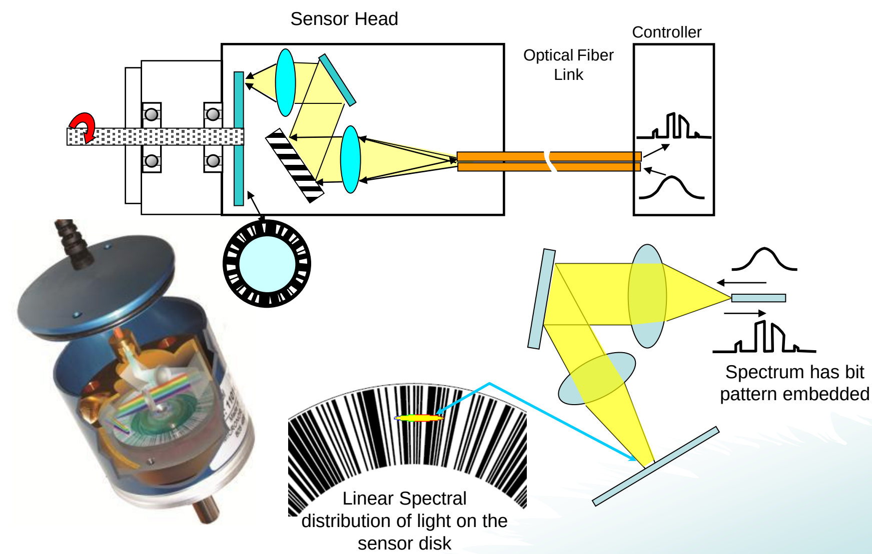
How The MR330 Works



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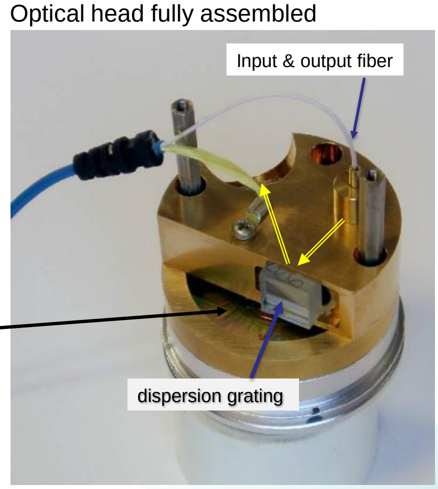
Inside The MR332/MR338 Sensor

Code disk mounted on rotating shaft

Optical head fully assembled



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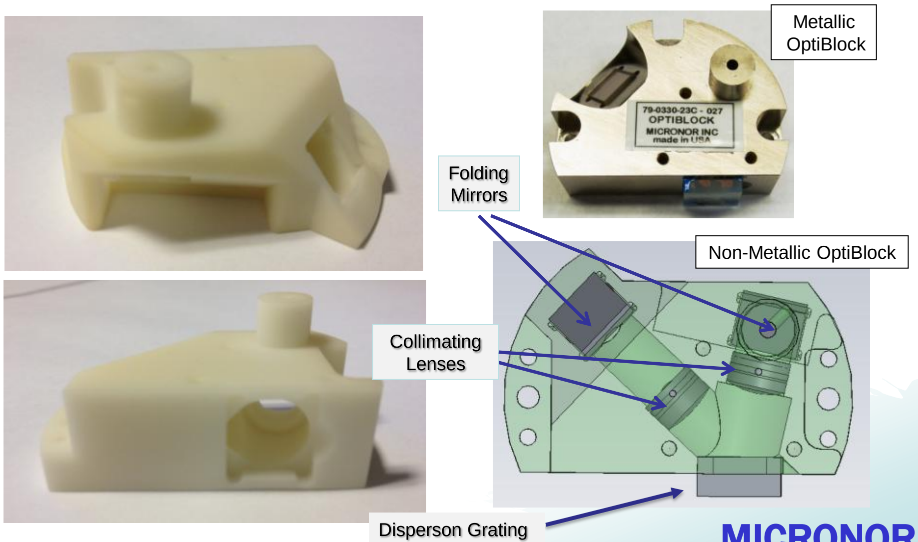
The Critical Component
Non Metallic OptiBlock



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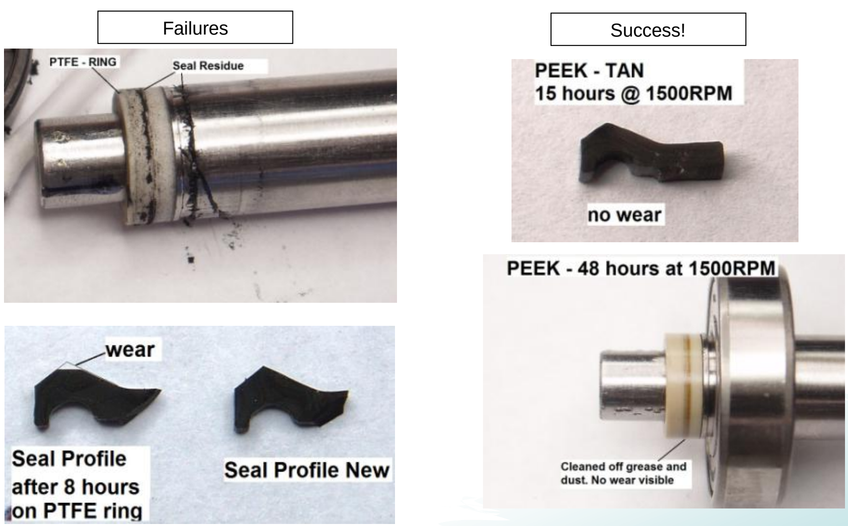
The Critical Component
Non-Metallic Shaft Seal



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